Inferred Spawning Areas and Seasons of Groundfishes on the Scotian Shelf

J. S. Scott

Biological Station,
St. Andrews, N.B., EOG 2XO

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INFERRED SPAWNING AREAS AND SEASONS OF GROUNDFISHES ON THE SCOTIAN SHELF

by

J. S. Scott

Marine Fish Division
Department of Fisheries and Oceans
Biological Station
St. Andrews, New Brunswick E0G 2X0
Canada

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ABSTRACT

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Catch records from 43 research survey cruises on the Scotian Shelf for the period 1970-1981 were examined to determine the location and catch rates of ripe and spawning groundfishes. Data on 12 major species were plotted to produce maps which may indicate spawning distributions and major spawning areas; monthly distributional plots of ripe and spawning fish were examined to determine probable spawning times. For most species, spawning distributions correspond to a large degree with normal summer distributions, but there is evidence for some concentration of fish during the spawning period.

RÉSUMÉ

Scott, J. S. 1983. Inferred spawning areas and seasons for groundfishes on the Scotian Shelf. Can. Tech. Rep. Fish. Aquat. Sci. 1219: iii + 14 p.

Nous avons analysé les rapports des prises de 43 campagnes de relevés de navires de recherche sur le plateau Scotian entre 1970 et 1981 en vue de déterminer la distribution et les taux de capture de poissons de fond sur le point ou en voie de frayer. Les données de 12 espèces majeures ont été traitées de façon à produire des cartes susceptibles d'indiquer les principaux lieux de ponte; les graphiques montrant la répartition mensuelle des poissons sur le point ou en voie de frayer ont été examinés afin de délimiter les périodes de ponte. Pour la plupart des espèces, la distribution des poissons reproducteurs correspond, dans une bonne mesure, à la distribution estivale de ces mêmes espèces, mais on observe une certaine concentration au moment de la ponte.

INTRODUCTION

Groundfish research survey cruises have yielded a substantial body of information on the distribution (Scott 1976) and environmental factors affecting various fishes (Scott 1982) on the Scotian Shelf (Fig. 1). Little is documented, however, on the temporal and spatial distribution of spawning fish in the area, although this relates to one of the most vital aspects of their life history and is the basis for determination of spawning stocks on which stock delineation and assessment are determined. An exception to the lack of information occurs in the case of haddock. Major spawning areas are known on Browns Bank and in the Emerald Bank area (Leim and Scott 1966) (Fig. 1). The spring spawning concentrations provided bonanza fisheries in the 1960's and early 1970's, but overfishing was so severe that initial protective quotas were followed by complete closure of the Browns Bank area to fishermen during the spawning period, which is still in effect. These measures are credited with being a major factor in the resurgence of the Northwest Atlantic Fisheries Organization (NAFO) Division 4X haddock stock and illustrate the practical importance of even generalized knowledge of marine fish life history.

The routine biological sampling procedures followed on research cruises provide a means of determining spawning localities and, within the restricted annual survey periods, also spawning times. Survey results are presented here as a first attempt at delineating spawning areas and seasons of most of the major groundfishes, although O'Boyle et al. (in press) also attempted to determine spawning times and concentrations of a few selected species on the basis of egg and larval distribution. Leim and Scott (1966) provide a good general account of spawning localities and seasons for many species.

MATERIALS AND METHODS

In the period 1970-81, 12 annual summer groundfish research trawling surveys and, from 1978-81, four spring and four autumn surveys were completed, each covering virtually all of the Scotian Shelf and the Bay of Fundy. In addition, several surveys gave partial coverage in winter, and several comparative fishing experiments have resulted in double coverage of the Shelf in summer in some years. In total, a large part of the year has been covered at one time or another (Table 1), and virtually the whole area has been well covered as exemplified in the 1974-79 summer research trawling surveys (Fig. 2). Each full survey comprised about 150 randomly selected stations on each of which a standarized 30-min haul was made, using either a #36 Yankee trawl or, in later years, a Western IIA bottom trawl. At each station, detailed biological examination was made of all commercially valuable species, except redfish, including determination of sex and sexual maturity. The latter was identified according to a standard scale of degree of maturation.

Stage	Designation	Stage	Designation
1	Immature	5	Spawning (Sp'g) or Ripe and Running (R & R)
2	Ripening 1 (R1)	6	Spent (Sp't)
3	Ripening 2 (R2)	7	Recovering (Rec)
4	Ripe (R)	8	Resting (Rest)

Table 1. Total numbers of research survey cruises in each month of years 1970-81.

Month	No. of cruises	Month	No. of cruises
January	2	July	17
February	2	August[a]	-
March	14	September	2
April[a]	-	October	4
May	-	November	1
June	-	December	1

[a]Partially covered by some "March" and "July" surveys.

A general characteristic of marine fish is that they concentrate for spawning and disperse afterwards. Because of this, only fish in the "Ripe" and "Spawning" categories were considered for delineation of spawning areas. For each species, therefore, geographic distributional charts were prepared by computer which showed the total number of specimens caught in each tow, in each maturity stage, (a) by sex, (b) by month, (c) by all months combined. Data for all years were combined to improve definition of spawning areas, making the necessary assumption that spawning areas and seasons are fairly consistent from year to year. Preliminary examination of the charts showed that distributions of males and females were indistinguishable at the scale used, so females only were used for the distribution charts.

RESULTS AND DISCUSSION

ATLANTIC COD (GADUS MORHUA)

Ripe cod were concentrated in the Browns Bank area in particular but were widespread over the Emerald to Banquereau Banks area and there was a significant concentration in Sydney Bight (Fig. 3A). There were minor occurrences in the Bay of Fundy and associated with Baccaro and LaHave Banks. Most records were in depths less than 50 fm (91 m) but the distribution extended out to the 100-fm (182 m) contour. Distribution records of spawning cod were more sparsely distributed (Fig. 3B) but corresponded in general to those of ripe cod; the distributions suggest, however, that the cod moved up onto the Banks as maturation proceeded. Ripe and spawning cod were notably absent from the central part of the Shelf in the Emerald and LaHave Basins area.

The rather dispersed spatial distribution of cod spawning accords with general field observations which suggest widespread spawning and resultant widespread distribution of larvae and juveniles (O'Boyle, in press).

Examination of monthly distributional maps (Fig. 4) suggests that, although there may be a few ripe cod over a large part of the year, intensive concentration of ripe and spawning fish occurs in March on Browns Bank, with lesser concentrations on Western and Emerald Banks. By June, spawning ceased on the western part of the Shelf but in July there were ripe and spawning cod on the northern part of Sable Island Bank, on Middle and Banquereau Banks, and in Sydney Bight. There are insufficient data for August and September but in October ripe and

spawning fish were distributed widely over Sable Island Bank, Middle Bank, and the eastern part of Banquereau Bank. In November and December there were sparse records of ripe fish on Western Bank.

It appears that there are two main periods of spawning activity in cod on the Shelf: (1) in March on Browns Bank (and in the Bay of Fundy) and the central Shelf, with minor spawning to the east, and (2) in October on the eastern part of the Shelf. Besides these, in July there is minor spawning activity over the Shelf to the east of Browns Bank and in Sydney Bight.

HADDOCK (MELANOGRAMMUS AEGLEFINUS)

Haddock spawning areas are highly concentrated in the Browns and Emerald Bank areas with only scattered occurrence of ripe and spawning fish associated with most of the other Banks and extending into the Bay of Fundy (Fig. 5A, B). There was no evidence of spawning on Sable Island Bank but small numbers of spawning fish were recorded on the eastern shallows of Banquereau Bank and in the Sydney Bight area. This, in association with juvenile haddock on the eastern Shelf (Scott, unpublished) may indicate a minor spawning stock, separate from the Browns and Emerald stocks. The spawning concentrations were all within the 100-fm (182 m) depth contour and mainly within the 50-fm (91 m) countours.

Ripe and spawning fish were found occasionally throughout the year, but the principal time of occurrence of spawning haddock was March in both Browns and Emerald Banks areas. Concentrations of spawning fish in April on Emerald Bank may indicate a slightly later, or more extended, period of spawning there.

The high concentrations of ripe and spawning fish make haddock particularly suitable for examination of movement of the fish into spawning areas as they mature. For this purpose the distribution of late ripening (R2) haddock was examined (Fig. 5C). The R2 fish were most highly concentrated in the same areas as ripe and spawning fish, but the distributions extended further to the east from Browns Bank and to the northeast of Emerald Bank than in the case of the ripe and spawning fish. There was also a greater representation of R2 fish over the area between Browns and Emerald Banks and notable records in the Gully and along the edge of Banquereau Bank. There is obviously a movement of mature haddock from a fairly wide dispersal over the Shelf to high concentrations in the spawning areas.

Another notable feature of the R2 distribution was a concentration of haddock on the northeast part of Georges Bank in March (Fig. 5B). This was not reflected in the distributions of ripe and spawning fish and may indicate a migration of maturing fish away from Georges Bank, possibly to Browns Bank.

RED HAKE (UROPHYCIS CHUSS)

Records of ripe red hake were scattered over the central part of the Shelf and in the Bay of Fundy at all depths, with no indication of concentration (Fig. 6). Records of spawning fish were extremely scarce. Almost all records of ripe and spawning fish were from July, indicating summer spawning. The presence of abundant red hake larvae in August-September (Markle et al. 1982) indicates that spawning should be in July, and high concentrations of larvae in the central part of the Shelf, presumably indicating the hatching area, agree with the survey data.

WHITE HAKE (UROPHYCIS TENUIS)

There were few records of ripe or spawning white hake in the surveys. There was no evidence of spawning concentrations but ripe fish occurred mainly in deep water along the edge of the Shelf and in the Fundian and Laurentian Channels (Fig. 7). The only records of spawning females (not shown) were from the Laurentian Channel, south of Banquereau Bank, and in the Fundian Channel. Spawning males were recorded from these areas also, but mainly from the central area of the Shelf between Western and LaHave Banks in 50-100 fm (91-182 m).

Virtually all records of ripe and spawning fish were made in July, suggesting summer spawning in accordance with Bigelow and Schroeder's (1953) observations in the Gulf of Maine. Markle et al. (1982) draw attention to the confusing situation regarding white hake reproduction, with evidence for spawning at all times of the year, depending on location.

SILVER HAKE (MERLUCCIUS BILINEARIS)

Although there were a few records of ripe and spawning silver hake along the edge of the Scotian Shelf in March, significant numbers did not appear until July. At this time ripe fish were distributed all along the edge of the Shelf from Browns and Banquereau Banks, over the whole of the central part of the Shelf east of LaHave Bank and on Banquereau (Fig. 8A). Spawning fish, however, were recorded mainly from Sable Island and Western Banks with a few records between Western Bank and Emerald Basin and on Banquereau (Fig. 8B). This indicates a movement of maturing fish to the Sable-Western area to spawn, and confirms previous interpretations of silver hake migration in the Scotian Shelf area (Clay 1979; Noskov et al. 1979). There was evidence of spawning on Browns Bank but not to the same degree as on the central Shelf.

After July, there were no records of ripe and spawning fish until September/October, mainly on the northeast part of the Shelf, suggesting a shift in spawning activity to higher latitudes as the year progressed. This accords with interpretations of other studies of silver hake spawning (Bigelow and Schroeder 1953), showing a sequence of spawning periods from off New England northwards along Georges Bank and the Scotian Shelf.

AMERICAN PLAICE (HIPPOGLOSSOIDES PLATESSOIDES)

Ripe plaice were widely distributed over the Shelf and along the Shelf edge from the Laurentian Channel westwards to a concentration on Emerald Bank, but sparsely scattered west from there to the Bay of Fundy (Fig. 9A). Records of spawning fish were lightly distributed in the same pattern (Fig. 9B) with no obvious concentration by area or depth, although almost all were within the 100-fm (182 m)

contour and most were within the 50-fm (91 m) countour on the Banks.

The spawning season for plaice is ill-defined, with spawning fish being recorded at all times of the year. Greatest numbers of records of spawners were in March and July, corresponding to principal survey months, but in September-October, another principal survey period, records were scarce. This suggests a spring-summer spawning season, rather more extensive than that of plaice in the southern Gulf of St. Lawrence (Powles 1965) and the Newfoundland Grand Bank (Pitt 1982a).

YELLOWTAIL FLOUNDER (LIMANDA FERRUGINEA)

This flounder is largely confined to depths less than 50 fm (91 m) (Scott 1982) and is more or less restricted to the offshore banks (Scott 1976). Concentrations of spawning fish were distributed over Banquereau, Sable Island, Western and Browns Banks and there was a high concentration on the west side of Emerald Bank (Fig. 10B), as in the case of American plaice. There were no records of ripe or spawning yellowtail flounder from LaHave or Baccaro Banks, but a few records of ripe fish from Roseway Bank and the Bay of Fundy. Major spawning concentrations were on Western Bank and the south part of Sable Island Bank (Fig. 10A).

Records of spawning fish were concentrated in July, although records of ripe fish occurred throughout the year. Summer spawning is suggested by Bigelow and Schroeder (1953) but these authors also give evidence for minor spawning activity over several months on each side of the major spawning period in the Gulf of Maine. Pitt (1970) notes summer (May-July) spawning of yellowtail on the Newfoundland Grand Bank, with a peak in June.

WITCH FLOUNDER (GLYPTOCEPHALUS CYNOGLOSSUS)

Distribution of ripe witch flounder was similar to that of American plaice, with the major concentration widely distributed over the northeast part of the Shelf and a sparse scattering of records from Western Bank to the Bay of Fundy (Fig. 11A). Local concentrations of ripe females were evident along the western edges of Sable Island and Western Banks. Records of spawning fish were scattered along the Shelf, well inside the 100-fm (182 m) countour and mostly in the Banquereau Bank area (Fig. 11B).

Spawning fish were found from March to July, with most records in the latter month. The fish is known to have an extensive spawning season from late spring to late summer in the northwest Atlantic (Pitt 1982b; Bigelow and Schroeder 1953).

WINTER FLOUNDER (PSEUDOPLEURONECTES AMERICANUS)

Winter flounder has a very restricted distribution on the Scotian Shelf, mainly concentrated on Sable Island Bank and in the Bay of Fundy (Scott 1976). This was reflected in the records of ripe fish which were limited to those areas, particularly the Bay of Fundy, plus the mouth of St. Mary's Bay and Browns Bank (Fig. 12A). The only records of spawning fish were off St. Mary's Bay (Fig. 12B).

There were a few records of ripe fish in January and July but most records of ripe fish and all records of spawning fish were in March. This agrees with observations by Bigelow and Schroeder (1953) who report the fish as a winter and early spring spawner in New England, with a progressively later breeding season northwards along the North American coast. McCracken (1963) noted peak spawning of winter flounder in May in Passamaquoddy Bay, possibly because of delayed warming of the waters there in comparison with offshore waters.

DISCUSSION

Standard research surveys produce information on locations and times of spawning which is otherwise unavailable, but there are evident shortcomings in using the surveys as a data base for this purpose. The most obvious and serious fault is the fact that the surveys cover only a few discrete parts of the year, and those very unevenly (Table 1). The month of July is by far the best represented, as the annual groundfish trawling survey has centered on that month each year since 1970, with a few extensions into June and August, depending on vessel availability. March and September-October are fairly well represented as they are the periods of annual spring and autumn surveys. The remaining months are covered by a few cruises, and some not at all. April and June were partially covered by some March and July cruises but May is missing. Fortunately, the March period appears to be the most representative single month for spawning of the major groundfishes, one of the reasons for choosing that month for spring surveys. With the low representation of cruises from November to February, there are no data on winter spawners. The two most obvious common species missing because of this are pollock, which has recently been identified as a spawner on the Shelf (McGlade, pers. comm.), and sand lance, an important forage fish which has a well-defined winter spawning period (Scott 1968). Maturation data for abundant but non-commercial species such as skates and dogfish, and minor commercial species, such as wolffish, are not recorded. Redfish is not included for the same reason, plus the fact that definition of maturation in redfish is complicated because the fish is a live-bearer, so the "spawning" condition occurs sometime after fertilization in the female, possibly in a different area.

A notable feature of the distributions of the inferred spawning areas is that, for the respective species, they show no obvious differences from spatial distributions of eggs and larvae (O'Boyle, in press) or summer (mostly non-spawning) distributions (Scott 1976), and do not indicate special, localized spawning areas distinct from 'normal' distributions. This may be the result of using generalized surveys. Precise delineation of spawning areas may require specific and intensive surveys aimed at individual species.

With the above reservations, the survey data nevertheless yield both new and confirmatory evidence for groundfish spawning times and locations and, with increasing survey activity at different times of the year, further improvement of our knowledge of fish reproductive behavior should be seen in the future.

ACKNOWLEDGMENTS

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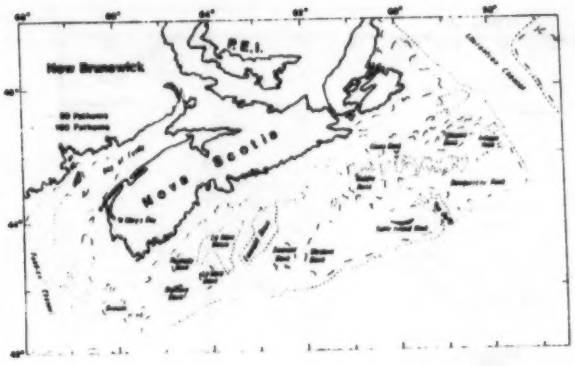


Fig. 1. Scotian Shelf and Bay of Fundy.

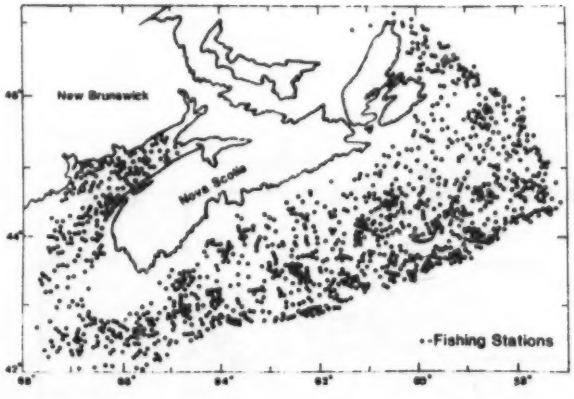


Fig. 2. Distribution of fishing stations on the Scotia Shelf during summer research trawling surveys 1975-79.

Fig. 3-12. Distributions of ripe and spawning groundfishes on the Scotian Shelf from research surveys 1970-81.

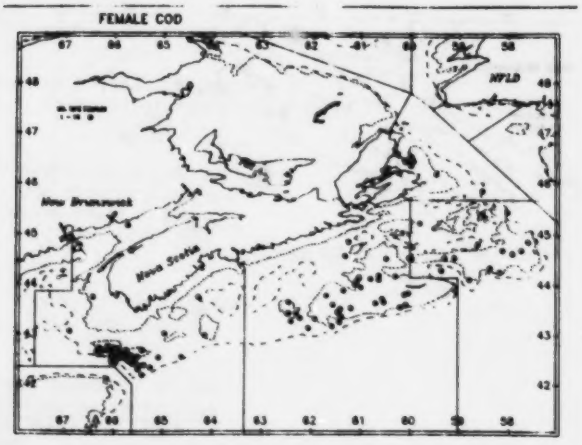


Fig. 3A. Cod - Ripe females

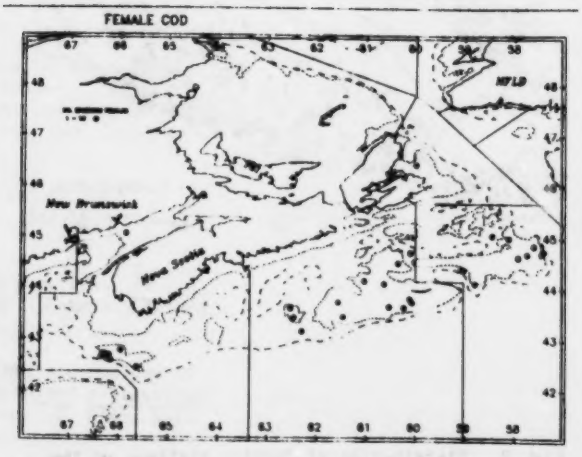
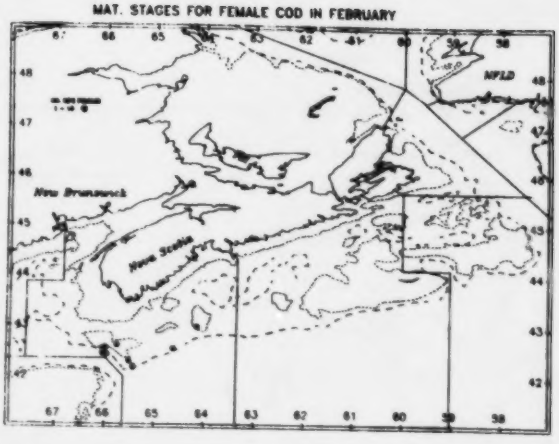
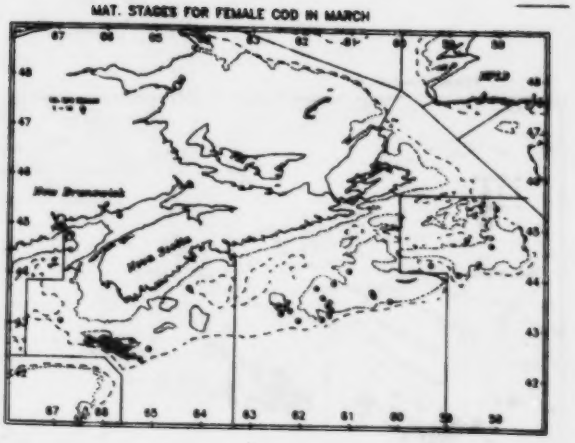
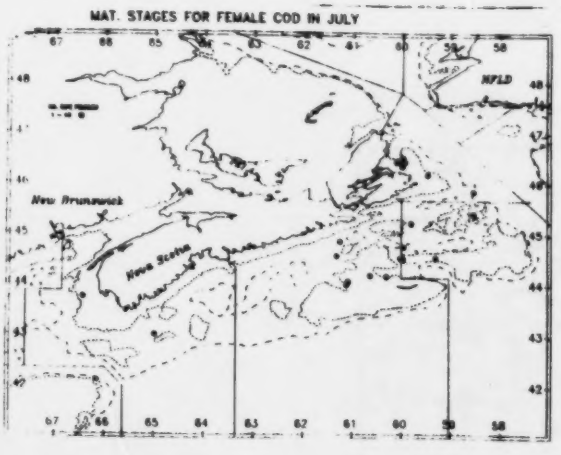


Fig. 3B. Cod - Spawning females







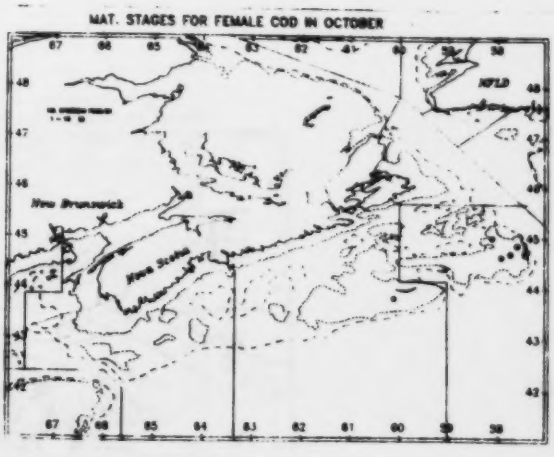


Fig. 4. Cod - Ripe female cod in February, March, July and October

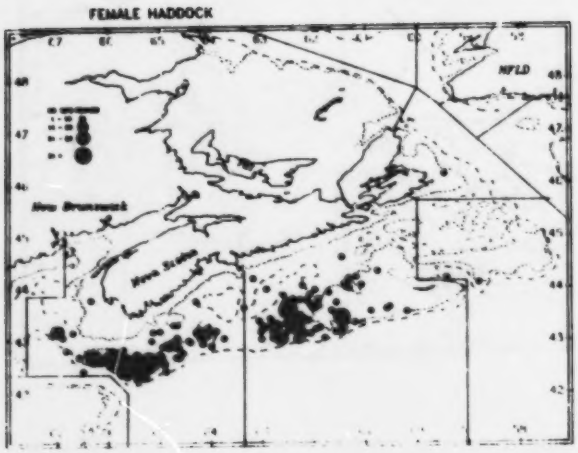


Fig. 5A. Haddock - Ripe females

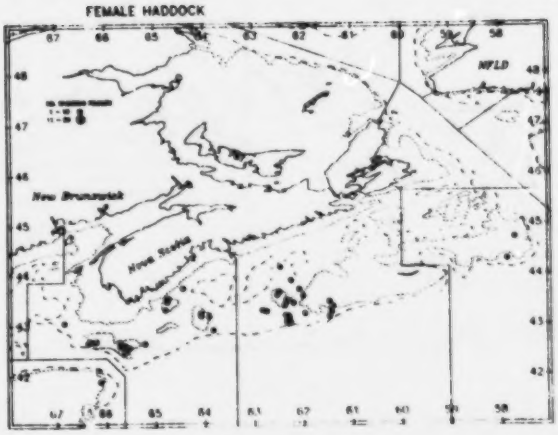


Fig. 5B. Haddock - Spawning females

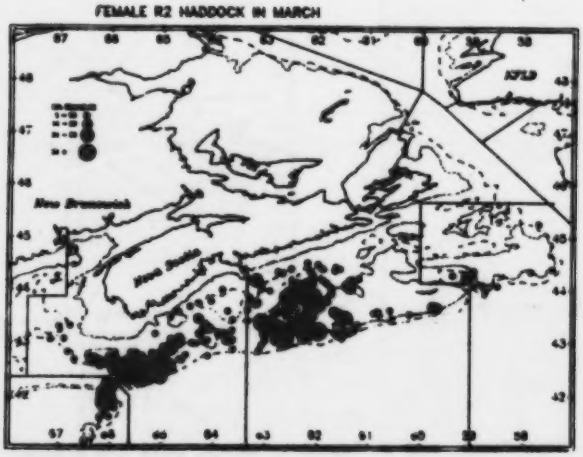


Fig. 5C. Haddock - Late ripening (R2) females

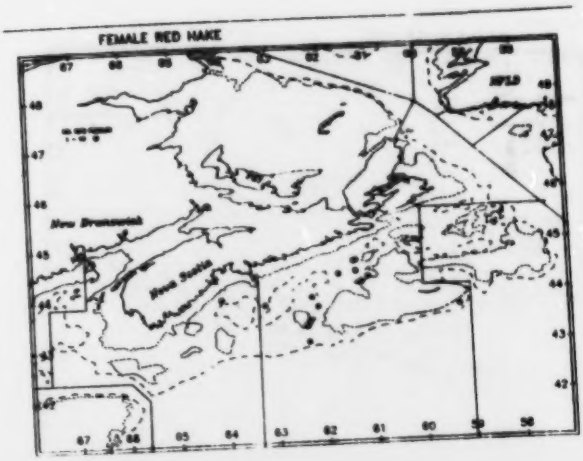


Fig. 6. Red hake - Ripe females

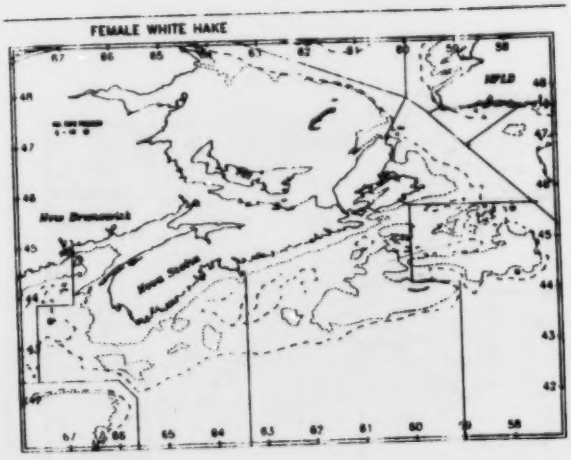


Fig. 7. White hake - Ripe females

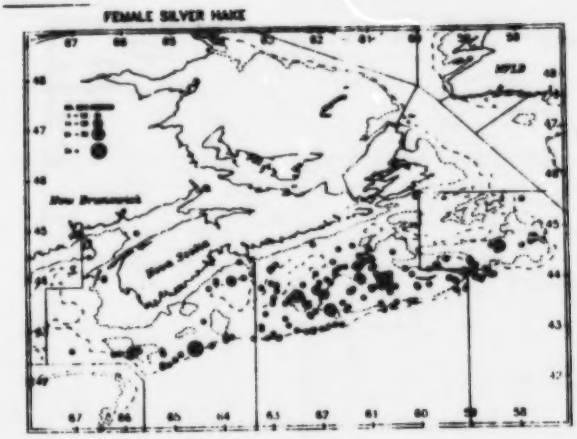


Fig. 8A. Silver hake - Ripe females

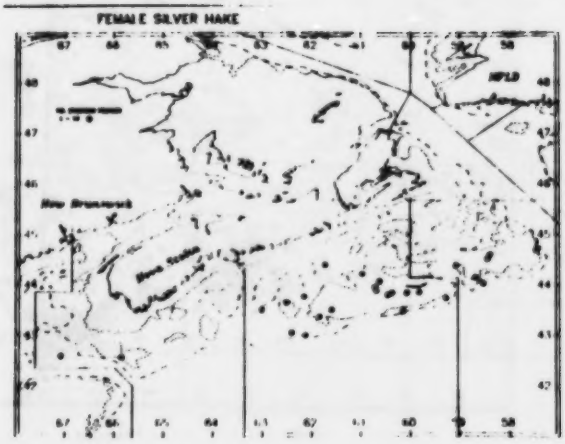


Fig. 8B. Silver hake - Spawning females

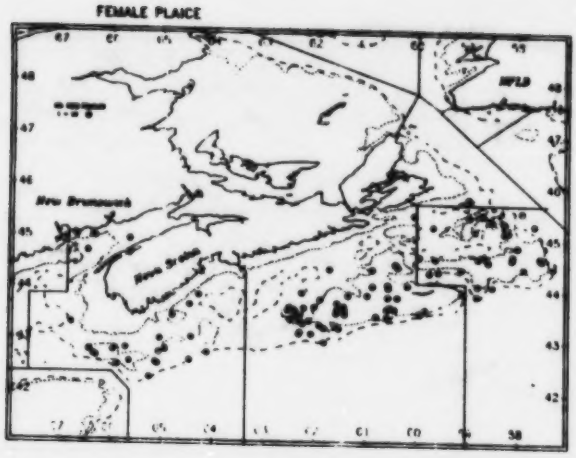


Fig. 9A. American plaice - Ripe females

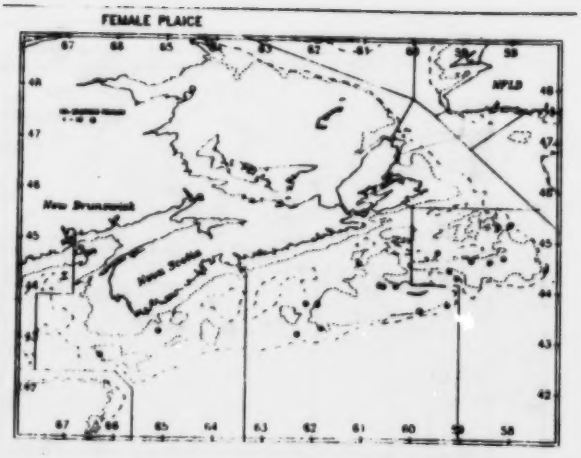


Fig. 9B. American plaice - Spawning females

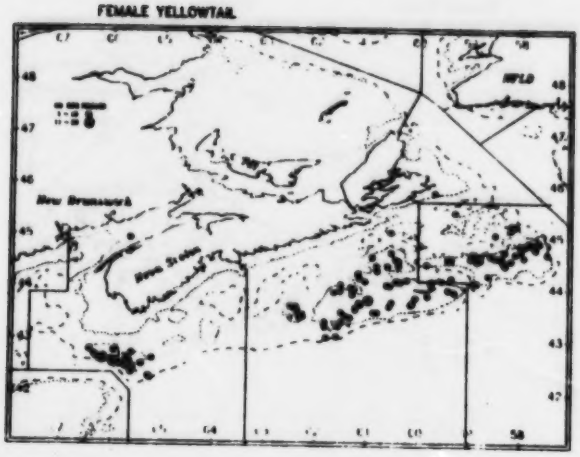


Fig. 10A. Yellowtail flounder - Ripe females

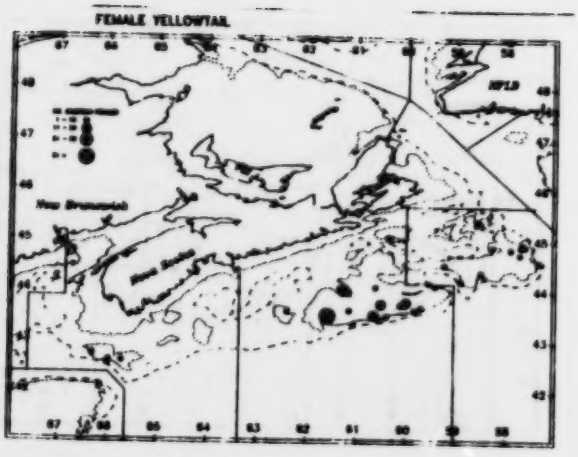


Fig. 10B. Yellowtail flounder - Spawning females

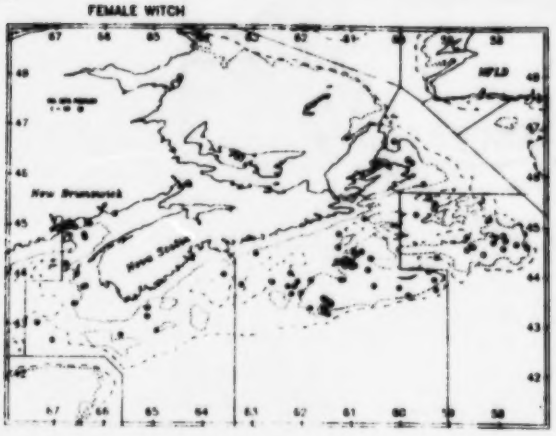


Fig. 11A. Witch flounder - Ripe females

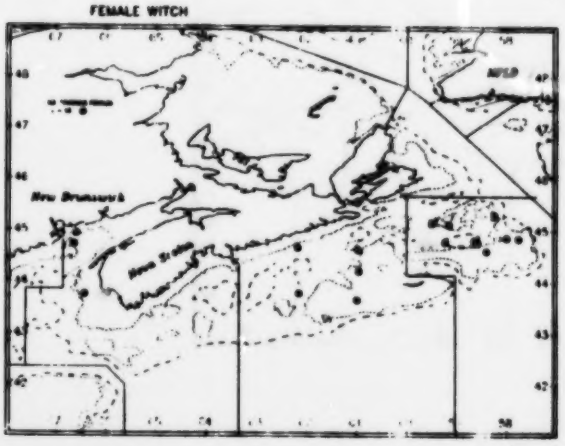


Fig. 11B. Witch flounder - Spawning females

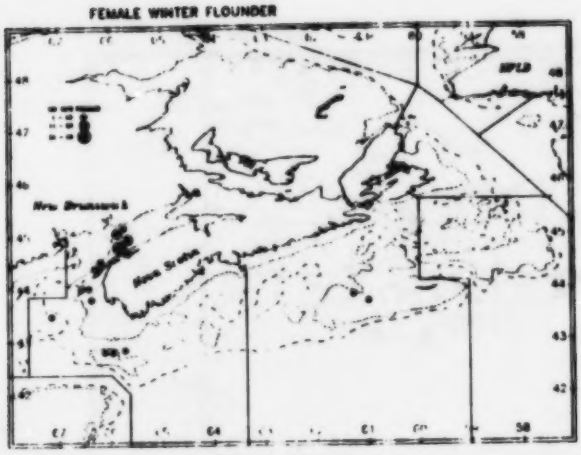


Fig. 12A. Winter flounder - Ripe females

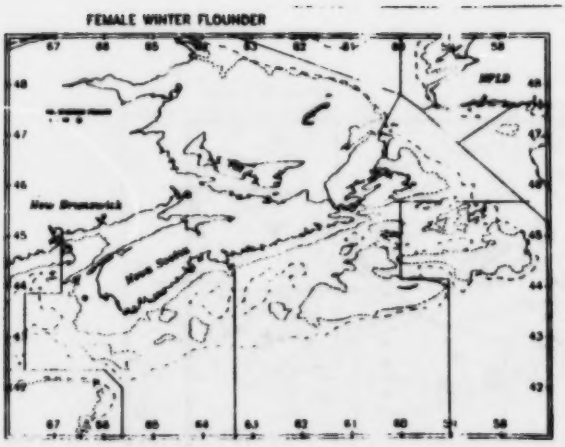


Fig. 12B. Winter flounder - Spawning females

POOR

QUALITY

ORIGINAL